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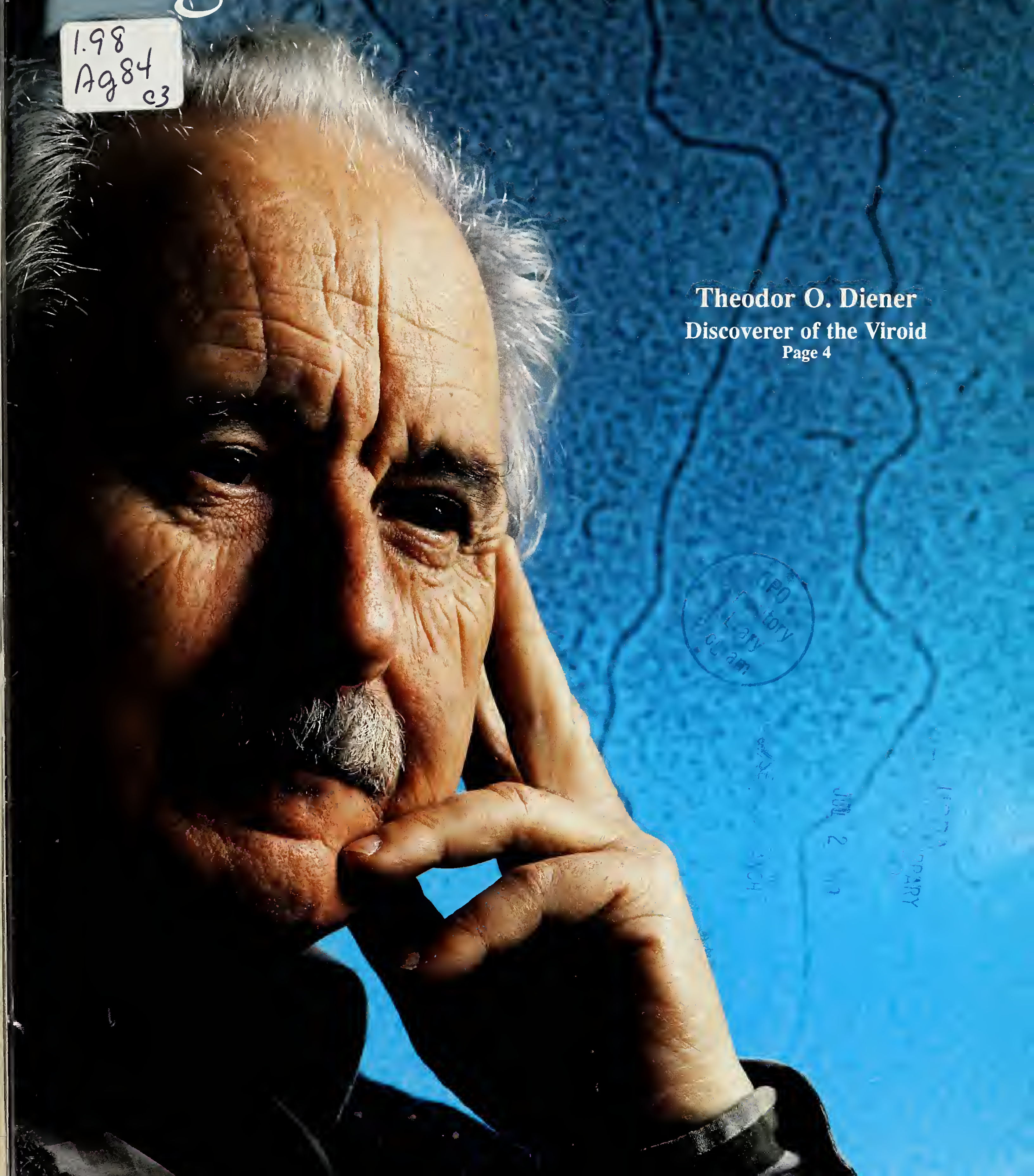
Agricultural Research



Theodor O. Diener
Discoverer of the Viroid
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Great Expectations and Practical Realities

This issue of *Agricultural Research* contains a story about the future: a story about new livestock—or at least new livestock characteristics—that may be fully established on farms and ranches by the year 2040. Another story, slated for an upcoming issue, is about special crops for space stations and the implications of closed-environment research for earth-bound agriculture.

Both of these stories, while based on solid research, are fueled by some rather inspired foresight. And that's not a criticism. Indeed, imagination is a vital part of the administration of science as well as the scientific process itself.

Without strong imaginations to inspire us, our expectations would take a downward turn and our achievements would surely follow.

But before we can fulfill dreams of the next century, we had better come to grips with today's realities. Our agency must soon confront several major challenges so we can meet our long-range research responsibilities. I have already discussed some of these challenges in recent budget testimony on Capitol Hill, and the response was encouraging. It may be useful to recap them here.

Facilities and Equipment: The first and perhaps foremost challenge is to provide our scientists with the facilities and state-of-the-art equipment and instrumentation they need. Many of our laboratories are old and outmoded.

Moreover, many of our scientific instruments were purchased 10 to 15 years ago—and at today's research and development pace that means they're obsolete. I am convinced that adequate facilities and equipment are unequivocally linked to success in modern science. It is urgent that we move forward with a strong program for modernizing our research workplaces.

Long-Term Funding and Long-Range Programs: ARS and the state agricultural experiment stations must have reliable, annually recurring funding support for long-term, problem-solving research projects. An axiom of such research is that its momentum not be interrupted. Effective programs and networks of scientists are assembled with great difficulty and, once dismantled, can rarely be reassembled.

A related challenge, now and in the future, is the need to find ways to adequately support long-range research programs that could be critical to agriculture in the future but that are not immediate high-priority needs. Economic constraints in recent years have already caused us to abandon numerous long-range programs in favor of short-range projects with more immediate payoffs.

Obviously, this is both a political issue as well as a scientific one. Nonetheless, we need to remember that future needs can become immediate needs more quickly than we expect, especially if we're not prepared for them.

The Erosion of Our Scientific Base: The 21st century will most assuredly confront us with the challenge of sustaining our historically high level of knowledge in the food and agricultural sciences. All projections point to shortages of graduates with degrees, particularly advanced degrees, in science and engineering. Efforts must be made to revitalize scientific education at all levels in our schools and to create new programs for the development of scientists and other professionals in agriculture.

Currently, to help identify and retain skilled new scientists, the ARS research associates program places recent Ph.D's in our laboratories to work alongside leading ARS scientists on priority programs. We aim to bring on board 100 qualified post-docs every year for 2-year appointments each.

The Cooperative State Research Service has proposed an expanded program to help the 1890 land-grant institutions and Tuskegee University recruit and graduate high-quality students in the agricultural and natural resource sciences.

The program would provide for grants to help these institutions update their curriculums in agriculture in cooperation with state, private, and federal partners. This would certainly increase the pool of available new scientists, and I believe it would pay enormous dividends down the road.

Technology Transfer: Last but hardly least on this list of major challenges is the need to effectively transfer our research developments and technology to the private sector. We must make sure that our research findings can be integrated quickly into the management systems of farmers, agribusinesses, various industries, and other users.

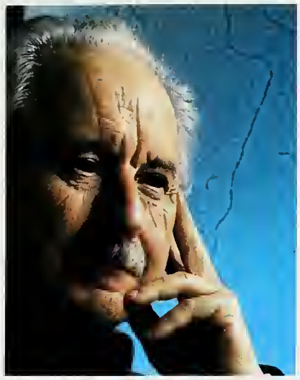
Equally important, we must continue to provide a route for feedback from users to researchers. Feedback indicates whether the integration of new technology into user operations has increased efficiency. And it identifies user needs for additional technology.

The function of technology transfer—the dissemination of research findings to the public—must remain the culmination of our research.

These challenges, as outlined above, need our attention now. But they do not call for a wholesale change in the way we're doing things. On the contrary, I am confident that we can prepare for tomorrow quite well within the framework of our existing system of agricultural research. While there will always be room for new initiatives in the administration of this agency, it will be equally important to retain and strengthen the best aspects of the research system that is now in place—a system that long experience has shown to be effective and excellent.

R.D. Plowman
Administrator

Agricultural Research



Theodor O. Diener, whose 1971 discovery of a plant pathogen 80 times smaller than a virus, took the scientific world by surprise. Story on page 4. Photo by Barry Fitzgerald. (K-3146-9)

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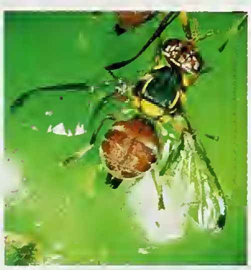

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DEPARTMENTS

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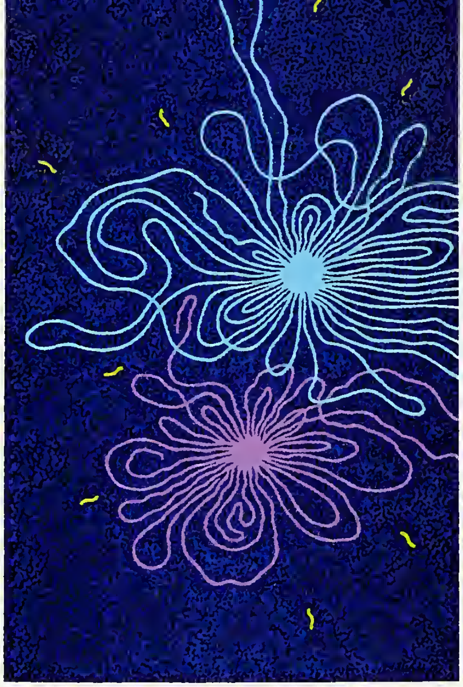


ROY NASH

The world's first known viroid appears as yellow-green rods in an artist's rendition of an electron microscope photograph.

Tracking the Elusive Viroid

According to accepted scientific dogma, the discovery of the viroid was not supposed to happen.

Finding out what causes potato spindle tuber disease brought about a small revolution in the study, diagnosis, and treatment of viral plant diseases. It also helped change approaches and attitudes in the study of livestock and human diseases.

But as crop diseases go, it wasn't very important. It didn't cost potato farmers millions of dollars in losses or control measures. Of course, if it got into a potato crop, it led to a second-year harvest of spindly, twisted tubers, but that didn't happen often.

Still, the disease made potato breeders nervous. For all they knew, the disease could sweep through their stock, damaging all the breeding potatoes in one year. And they wouldn't know why or be able to do much about it.

And it nagged at plant pathologists. They couldn't figure out what agent caused the disease. After eliminating all the other possibilities, they concluded that it was some kind of virus, even though it didn't behave the way a virus should.

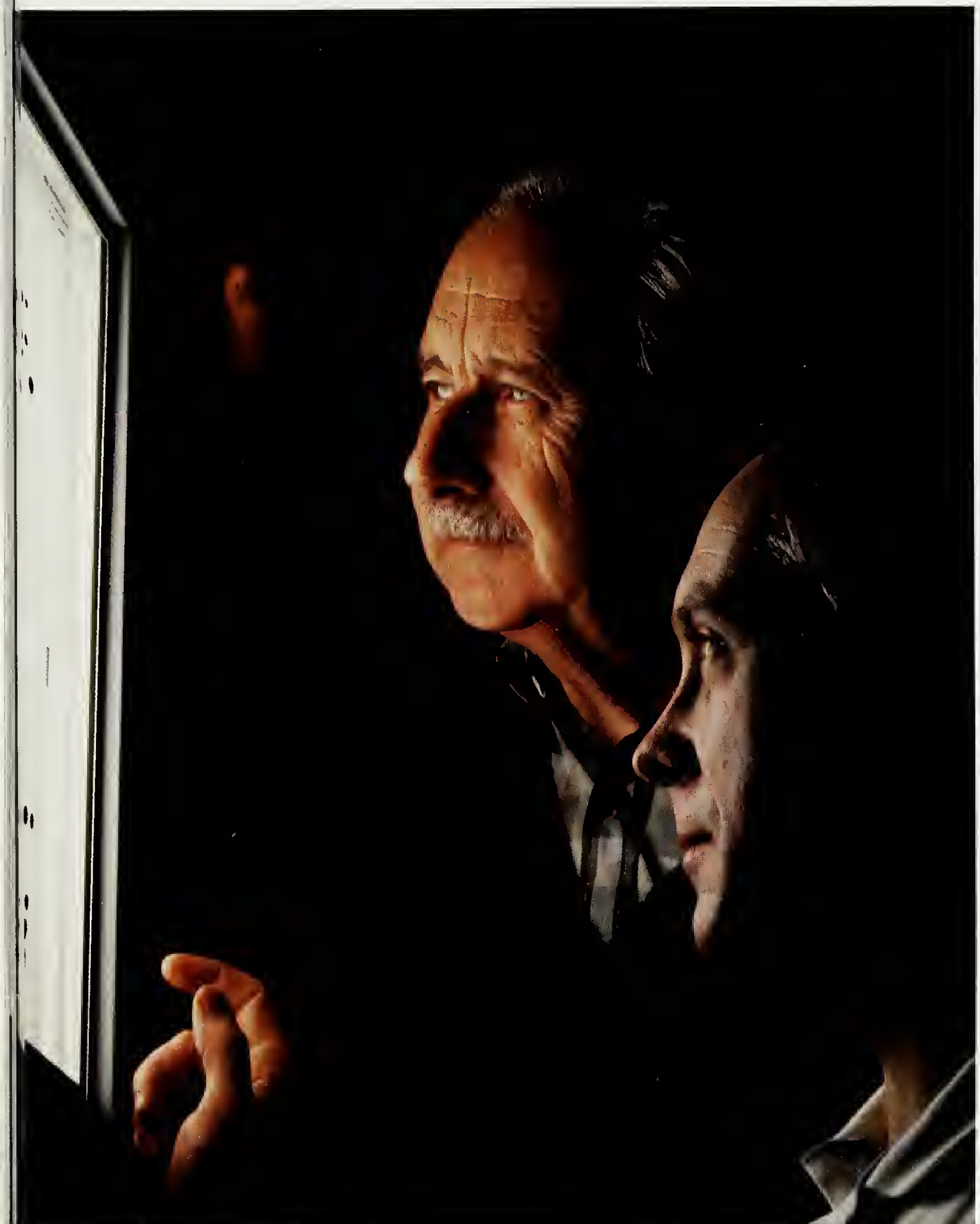
But it wasn't a virus. It was something entirely new.

Potato spindle tuber and at least 15 other crop diseases are caused by viroids, an entity that nobody had ever heard of before 1971, its official date of discovery. Theodor O. Diener, the Agricultural Research Service plant pathologist who discovered the pathogen, named it the "viroid," because it is "like a virus."

Like a virus, the viroid invades a cell and hijacks its reproductive mechanisms. It forces the cell to duplicate the viroid's RNA instead of its own. The viroid has no DNA. RNA and DNA are nucleic acids, the molecules of heredity; with the exception of viroids and some viruses, all genes are made of DNA. The difference between viroids and RNA viruses is that viroids have no protective protein coat. The scientific dogma in 1971 was that an organism with no

THEODOR DIENER

Growth stunting and leaf distortions in tomato plant on right are caused by the potato spindle tuber viroid. (K-3144-1)



Theodor Diener (left) and Robert Owens examine developed film from a potato spindle tuber viroid hybridization test used to develop a practical screening method for the viroid. (K-3147-1)

protein wasn't supposed to be able to replicate itself, even with a host cell's help. And an entity as small as the PSTV (potato spindle tuber viroid)—130,000 daltons—wasn't supposed to be able to infect anything, even a potato.

Until that time, scientists believed that the minimum weight necessary for infectivity was about 1 million daltons. (A dalton, also called an atomic mass unit, equals one-twelfth the mass of a carbon-12 atom.)

Diener wasn't much impressed by scientific dogma. He'd seen it turned upside down too many times. But he was very careful to prove that the viroid really existed. In all, it took him 6 painstaking years.

"Genius," said Thomas Edison, "is one percent inspiration and ninety-nine percent perspiration." The perspiration spent in pursuit of the viroid came in years of preliminary work by William B. Raymer, Diener, and many associates.

Raymer, also a plant pathologist, was at the ARS Potato Diseases Investigation Laboratory in Beltsville, Maryland, during the early 1960's. It was Raymer who began the project that eventually led to the discovery of the viroid.

"Perhaps the most important lesson to be gleaned from the discovery of the viroid is the importance of freedom for research scientists to follow leads when they become evident, rather than be tied down by too narrow a position description and predetermined goals."

Russell L. Steere, ARS botanist (retired), Beltsville, Maryland

It was Raymer and fellow ARS plant pathologist Muriel O'Brien who came up with a breakthrough in convenience in finding the cause of potato spindle tuber disease—a simple bioassay for the infectious agent.

Since spindle tuber takes a couple of years to show up in potatoes, results of many tests were excruciatingly slow to come. But Raymer and O'Brien found that the unknown pathogen was easily transmitted in tomatoes. Within 2 weeks, a growing tomato plant became dramatically stunted.

ROBERT OWENS

Potatoes deformed by the potato spindle tuber viroid. As successive generations of infected potatoes are grown, the disease symptoms become more severe. (K-3145-1)

Now they could get lots of diseased leaves quickly. High-speed centrifugation, a standard method to purify viruses, would surely turn up the virus, thought Raymer and O'Brien. "Bottling" the virus, capturing it, seemed imminent.

Not exactly. The standard method produced such low amounts of infection that it was clear the cause of potato spindle tuber disease was not a typical virus.

Baffled, Raymer went to Diener, who had recently joined the new Plant Virology Pioneering Laboratory, one of 16 pioneering labs set up by ARS to define the laws and principles of basic problems in agriculture.

Russell L. Steere, botanist and chief of the lab, would later say that "perhaps the most important lesson to be gleaned from the discovery of the viroid is the importance of freedom for research scientists to follow leads when they become evident, rather than be tied down by too narrow a position description and predetermined goals."

For a year after they teamed up in 1965, Raymer and Diener gradually put to rest the notion that potato spindle tuber disease was caused by a virus. They tried a different form of centrifugation, developed by Myron K. Brakke, an ARS chemist.

His density gradient centrifugation technique showed that the pathogen was small and light. So it was unlikely, says Diener, "that the agent was a conventional viral nucleoprotein. It appeared more likely that this material was a free nucleic acid."

Procedures in enzyme chemistry were next. Diener and Raymer treated extracts of diseased tomato leaves with an enzyme that chews up RNA. With RNA removed from the extracts, the scientists discovered that the treated extract failed to reinfect healthy tomato plants as it had before the enzyme treatment.

RNA in the agent was clearly important. But treatment with enzymes that remove DNA or protein made no difference; neither changed the pathogen's ability to infect tomato plants.

The results told Diener and Raymer that the essential ingredient of the spindle tuber agent was RNA and that it contained no protein.

At this point, in 1966, Raymer left for a job in private industry. Diener spent the next 5 years isolating and characterizing the viroid, verifying his experiments, filling in the holes, preparing to meet the skepticism that generally greets proposals of new, "impossible" concepts.

His concept did meet some resistance, chiefly from animal virologists and medical researchers unfamiliar with his earlier work, but his carefully prepared evidence was overwhelming. And as is often the case, another scientist working on another disease came up with a similar proposal at roughly the same time.

In 1975, Diener was co-recipient of the Alexander von Humboldt Award, which is presented each year for the most significant contribution to agriculture or the agricultural sciences for the past 3 to 5 years.

Spinning Off the Viroid

Since 1971, viroid research has spun off into two directions. One of these is the search for similar subviral pathogens as agents of livestock and human diseases.

The more immediately practical spinoffs are rapid, accurate diagnostic tests to keep viroid diseases out of potato, tomato, citrus, coconut palm, grapes, hops, chrysanthemums, and other crops.

The need to come up with diagnostic tests for the strange pathogens became evident to Diener when he attended a 1980 planning conference of the CIP (International Potato Center) in Peru. There he learned that CIP scientists were quite anxious about potato spindle tuber disease, which is a particular threat to potato crops in warm climates.

Although potato plants normally do best in cool weather, CIP is breeding plants for warmer climates. Diener returned to Beltsville, and in a few weeks, he and chemist Robert A. Owens developed a diagnostic test for PSTV that received a U.S. patent in 1984.

Their technique uses cloned, radioactive DNA copies of the PSTV RNA. Potato plant juice is spotted onto a sensitive membrane, which is then immersed into a solution of the radioac-

LES SAUGIER

Symptoms of the apple scar skin viroid aren't apparent until an apple tree sets fruit. (K-3143-1)

tive probe. If the spot appears dark on a photograph of the membrane, the viroid is present.

Within 2 years, most potato breeders in the United States were using the technique, according to Chett Sutula, president of AGDIA, Inc. His company markets a kit for testing up to 100 samples of potato tissue for PSTV at once, based on the Owens-Diener technique. Nearly all potato breeders and seed certification programs in the world, including those at CIP, use variations of the new technology.

The latest viroid tests, developed in 1988-89 with genetic engineering technology, will help prevent the spread of apple scar skin, a devastating apple disease, from Asian to U.S. orchards.

Like potato spindle tuber and other viroid-caused plant diseases, apple scar skin is extremely difficult to find and quarantine. Symptoms aren't apparent in an apple tree until it sets fruit. Then apples shrivel and crack. In China and Japan, whole orchards have been rendered useless by its attacks.

BARRY FITZGERALD

ARS plant pathologist Ahmed Hadidi examines a radiograph of apple scar skin viroid. (K-3149-1)

The new test, developed by ARS plant pathologist Ahmed Hadidi and cooperating scientists in Japan, detects apple scar skin viroid in less than 2 weeks. It will be used at the National Plant Germplasm Quarantine Center in Beltsville, Maryland, and in Canada and other countries to monitor and control the disease worldwide.—By **Ruth Coy,** ARS. Based on "The Naked Intruder. USDA and the Discovery of the Viroid," a book by Stephen M. Berberich.

Theodor O. Diener, now retired, continues his research in the USDA-ARS Microbiology and Plant Pathology Laboratory, Beltsville, MD 20705 (301) 344-2745. He is also affiliated with the Maryland Biotechnology Institute, University of Maryland, College Park. Ahmed Hadidi is with USDA-ARS National Plant Germplasm Quarantine Laboratory, Beltsville, MD 20705 (301) 344-3003. ◆

Selenium-Loving Plants Cleanse the Soil

Plants that "eat" selenium might someday be used to prevent too much of this potentially toxic mineral from ending up in food we eat and water we drink.

When harvested and dried, selenium-accumulating plants could be blended with livestock feed, as a safe and natural substitute for the selenium that's frequently added to keep animals healthy.

And skillful genetic engineering might make selenium-gobbling plants even more useful. Fine tuning of natural genetic mechanisms might boost the plants' natural ability to remove selenium and various metallic compounds from contaminated fields, pastures, or drainage water.

Banuelos is looking for the ultimate selenium-eating plant—a hardy species that could thrive on saline, poor-quality soil. . . He may have found it.

Such are the schemes of scientists Gary S. Banuelos at the Water Management Research Laboratory, Fresno, California, and David W. Ow of the Plant Gene Expression Center, Albany, California.

Both are exploring new ways of preventing or cleaning up dangerous accumulations of selenium. An essential nutrient, selenium has been aptly named a Jekyll and Hyde element. Too little of it can lead to weakening of the heart (cardiomyopathy). But too much of it—signaled by a garliclike breath odor—can lead to severe liver and kidney damage or, in a handful of documented cases, death.

The Food and Nutrition Board of the National Academy of Sciences recommends 0.05 to 0.2 mg of selenium as "safe and adequate daily intake" for adults. That amount looks something like a few grains of salt.

Banuelos is looking for the ultimate selenium-eating plant—a hardy species that could thrive on saline, poor-quality soil that's rich with the mineral and could accept and use re-cycled irrigation water that carries even more of the substance to the plant.

He may have found it.

After testing 200 species already known to have a liking for selenium, he's pinpointed the best of the lot—wild mustard from Pakistan.

Seeds for his greenhouse tests, provided by the ARS Plant Introduction Station in Ames, Iowa, yielded yellow-flowered plants similar to those that grow wild throughout the West.

Banuelos raised the seedlings in soil loaded with selenium in its most accessible form, selenate. The dose—3.5 mg per 1,000 grams (2.2 pounds) of soil—is similar to that plants could encounter in this country's most selenium-rich regions.

Mustard easily took up about 60 percent of the mineral, with no signs of an overdose. Compare that with plants such as fescue grass, which took up only about 14 percent.

If mustard could do as well in fields as it did in greenhouse tests, five mustard crops a year could remove up to 50 percent of the selenium in the top 12 inches of soil, says Banuelos.

This year he will have a chance to find out what kind of cleanup job mustard does outdoors. With University of Arizona researchers, he'll monitor mustard plants in field tests near Fresno. University researchers want to see what sort of yields growers could expect if they planted the mustard, saltbush, or other species on marginal, saline soils, using only drainage water to irrigate the crop.

Banuelos expects salinity to slow—but not stop—mustard's cleanup action. That's what happened when he grew it in greenhouse tanks, with roots submerged in water similar to local drain water. Like water that's being used in the field study, greenhouse tankwater had a selenium-salinity-boron load typical of the area.

"No one talks about it, but boron is likely to be the next problem," he says. "Recycled irrigation water that has a high concentration of selenium usually has a high concentration of boron and salt, too."


CON KEYES

Looking for the ideal selenium-eating plant, soil scientist Gary Banuelos examines Australian salt bush mixed with fescue grass. (K-3138-3)

Banuelos' Fresno laboratory is about 75 miles from Kesterson Reservoir, where buildup of selenium in the food chain is blamed for deaths or deformities of coots, ruddy ducks, mallards, avocets, killdeer, grebes, and other birds.

How did it happen? Irrigation water, draining from cultivated fields into Kesterson's ponds, greatly speeded up the natural movement of selenium from nearby mountains. Those mountains were once a seabed where selenium was deposited.

Kesterson emphasized the need for fast, safe, economical ways to get rid of

excess selenium. Such tactics are needed not only for the troubled California refuge, but for other hot spots where similar problems could occur—or already have—as in Arizona, Wyoming, Utah, Nevada, and Montana.

Pollution by toxic elements has also been a force behind David W. Ow's interest in the complex—and mostly mysterious—internal workings of plants when they're exposed to the extra stress of growing in soils contaminated with heavy metals.

Ow says plants react by synthesizing large amounts of molecules known as phytochelatins. Scientists first discovered these unusual compounds in the yeast *Schizosaccharomyces pombe* and reported their find in the early 1980's.

Phytochelatins bind to such metals as cadmium, copper, zinc, and lead. Scientists suspect that they'll also attach to selenium.

In lettuce and spinach, phytochelatins and the metals they link with end up in leaves that we eat; in soybeans, the phytochelatin and metal accumulate mainly in roots, which we don't use.

Phytochelatins apparently determine how much of these metals the plants take up and perhaps even dictate where the minerals are stored, Ow says.

But how do plants make phytochelatins? What determines where the phytochelatins will hide the incoming metals? His research may answer these questions. Scientists might then have the option of revving up intake of metals by plants we don't eat—a cleanup strategy.

Biotechnology may also help plants that are intended for the dinner table. Gene messages in crops that have an affinity for selenium, such as broccoli and swiss chard, could perhaps be changed, so that the plant would routinely shunt incoming selenium into parts we don't eat.

Or the signals could be modified so that plants store "only minimal, harmless amounts" of these metals in sections we eat, Ow says.

His approach is to pinpoint genes responsible for producing phytochelatins, to find out how the genes are put together, and to figure out what makes them start—or stop—working.

For these experiments, he's working with cadmium, the yeast *S. pombe,* and two plants that are favorites for biotechnology research because they're easy to work with—tobacco and the weed *Arabidopsis.*

Experiments by other researchers suggest that plants make phytochelatins by taking the compounds glutamine and cysteine through several successive conversions.

By screening more than 10,000 yeast colonies, Ow and colleagues have discovered some colonies that, when exposed to cadmium, seem to have glitches in the proposed conversion process.

Studying these natural defects might reveal new clues about how normal plants manufacture phytochelatins—a process that scientists can now only guess at.

Called a "biochemical pathway," the process is "with few exceptions, unique to the plant kingdom," according to Ow. The pathway is also one that may take researchers years to chart with any certainty. But knowing more about how plants cope with heavy metals should help us, too, live more safely with selenium.—By **Marcia Wood,** ARS, Albany.

Gary S. Banuelos is with USDA-ARS, Water Management Research Laboratory, 2021 South Peach Ave., Fresno, CA 93727 (209) 453-3116. David W. Ow is at the USDA-UC Berkeley Plant Gene Expression Center, 800 Buchanan St., Albany, CA 94710 (415) 559-5909. ◆

Selenium Poisoning

Problems with the element date back many centuries. Severely selenized cattle have been losing portions of their hooves since the days of Marco Polo, who visited western China and eastern Turkistan in 1275. He wrote:

"It is a fact that when [certain Chinese] take that road they cannot venture among the mountains with any beast of burden excepting those accustomed to the country, on account of a poisonous plant growing there, which if eaten by them has the effect of causing the hooves of animals to drop off.

"Those of the country, however, being aware of its dangerous quality, take care to avoid it."

In the New World, a similar animal disease, called Soliman disease, was known in Mexico more than 300 years ago. Livestock and human problems seemed to be associated with vegetation grown on outwash from certain mines in the vicinity of Irapuato.

Similar symptoms were reported in 1856 by a doctor who called attention to "a very fatal disease" among cavalry horses at Fort Randall, in what is now central South Dakota. Its cause was correctly linked to a problem with pastures, although the malady was incorrectly called "alkali disease."

In 1928, as a result of conferences with ranchers, Kurt Franke of the South Dakota Agricultural Experiment Station began collecting data on the so-called alkali disease of livestock and other poorly understood animal diseases of western ranges. Franke's work helped impel the U.S. Department of Agriculture to conduct its first conference focusing on selenium in 1931.

Final in a series beginning in the April issue of *Agricultural Research*

Farm Animals of the Future

Hudson Glimp dreams of the day when sheep can eat sawdust and sagebrush—and thrive. According to Glimp, that day could come in the 21st century. The secret, Glimp believes, will lie in development of a microorganism that can live in a sheep's stomach and break down lignin, the material that binds wood fibers.

Glimp is no idle dreamer; he's an Agricultural Research Service animal scientist and director of the U.S. Sheep Experiment Station at Dubois, Idaho.

"I think there's tremendous potential to engineer bacteria that could be introduced into the sheep so they could digest all sorts of things—sawdust, industrial byproducts, etc.," Glimp says. "This sort of thing happens naturally anyway. The bugs that help sheep digest milk are different from the ones to digest grass."

Glimp has plenty of other visions for 21st-Century sheep.

"We basically have four sheep production systems in the United States today—desert range, intermountain range, farm flock, and very intensive confinement," he notes.

"Fifty years ago, the desert range producers were selling a 70 percent lamb crop—70 lambs per 100 ewes. Now they're at about 85 percent. But if they're going to be in this business 50 years from now, they'll need to be selling a 150 percent lamb crop. We've got 2 to 3 percent of producers doing that right now.

"Today we have a handful of producers who use intensive confinement production, and they're producing a 200 percent lamb crop," Glimp says. "One neighbor out here is producing 400 percent. So I see no reason why 400 percent isn't an achievable goal by the year 2040."

Nationwide, Glimp says, the lamb crop averaged 85 percent 50 years ago, stands at 105 percent today, and could go

© GRANT HEILMAN

Faster growth, increased weight, and more lean meat are projected for lambs of the future.

ARS microbiologist Louis Gasbarre isolates white blood cells that provide immunity against gastrointestinal parasites of cattle. (K-3123-4)

to 220 percent by the year 2040.

"We don't need much more technology to do this," he says. "All we need is for market prices to make the extra management efforts economically feasible, and it'll happen."

Glimp cites the example of the Booroola Merino sheep, a type that originated on the Booroola Station in Australia.

"A genetic mutation happened about 40 years ago in some of those sheep, and if the particular sheep has that gene, it will have five or six lambs instead of one," he says. "The Booroola Merino sheep is a miserable sheep—but we could put that particular gene wherever we want it. That will be done in the next 5 to 10 years."

Glimp also sees average lamb slaughter weight at 5 months of age rising to 170 pounds by 2040, compared with 120 pounds today and 80 pounds 50 years ago.

"We've gone up almost a pound a year, and there's no reason to believe that trend won't continue," he says.

"As for the percentage of fat in the carcass, it will be down to 17 or 18 percent, compared with 27 percent now and 35 percent 50 years ago," he says. "The better producers are already at 17 or 18 percent.

"This will come through several things, but first of all selecting for a leaner, faster-growing animal."

Glimp says he expects trimmed lean meat per lamb to average 58 pounds by 2040, compared with 34 pounds today and 20 pounds in 1938.

Still Fewer Dairy Cows Needed

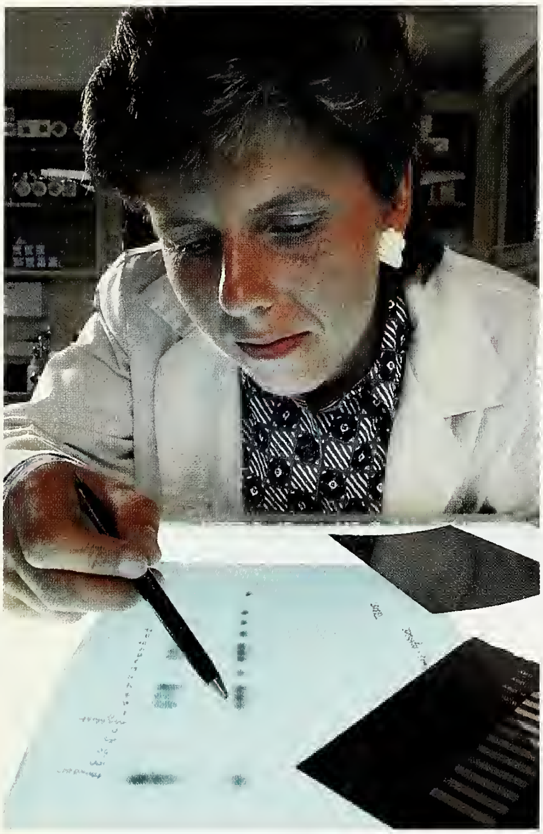
The big news in dairy cattle for the 21st century will be output—herds yielding as much as 40,000 pounds of milk per animal per year, according to H. Duane Norman, research leader of ARS' Animal Improvement Programs Laboratory at Beltsville, Maryland.

"We've had individual cows already that produced 50,000 pounds," Norman says. "In 1945, we had 25 million dairy cows in the United States; today we have about 10 million. But the milk yield per cow is up from 4,600 pounds to an average of 14,000 pounds today.

"Who would have said, back when we were making 4,600 pounds of milk, that we'd go to 10,000? We've got whole herds now that are producing 25,000 pounds."

The difference, says Norman, is genetic improvement, a steady selection process that sends older cows to slaughter and keeps only the best new animals on the milking line.

Through nationwide genetic improve-



KEITH WELLER

ARS biologist Donna King checks signature X-ray film of DNA samples. (K-2992-5)

ment efforts, Norman says, the cow that comes on line this year will be capable of producing 170 pounds of milk more per year than the cow that began milking last year "because she's a descendant of animals that produce more milk."

That's compared with an annual gain of 10 to 20 pounds prior to innovations in genetic evaluation and improvement starting in the early 1960's.

Will gigantic milk output necessitate gigantic cows? Maybe not, says Larry D. Satter, a dairy scientist at ARS' U.S. Dairy Forage Research Center at Madison, Wisconsin.

"The thinking goes that large body size and gut size are needed to process a large amount of nutrients to make milk," says Satter. "But if we had better nutrients that could be processed more quickly, maybe we wouldn't need so much room in the animal.

"That's why we're interested in seeing what can be done with cell walls. Most forages have moderate to low digestibility because of the cell wall, the tough layer that surrounds the cell contents.

"Currently, only 30 to 40 percent of the material in the cell wall itself is available to the animal. Our idea is to learn more about the nature of cells, how they differ from plant to plant, and how we can modify them and still have a healthy plant."

Shifting the Partitioning of Energy

Oddly, for all their gains, the modern dairy cow is still producing only 0.65 calorie of milk for every calorie of useful energy absorbed from the digestive tract, according to Henry F. Tyrrell, a research animal scientist in the Energy Metabolism unit of ARS' Ruminant Nutrition Laboratory at Beltsville.

"You can go back in the scientific literature 80 or 90 years, and the estimates were still 65 percent," says Tyrrell. "This says to me that the modern dairy cow, from a metabolic point of view, is no more or less efficient than the cow of 100 years ago."

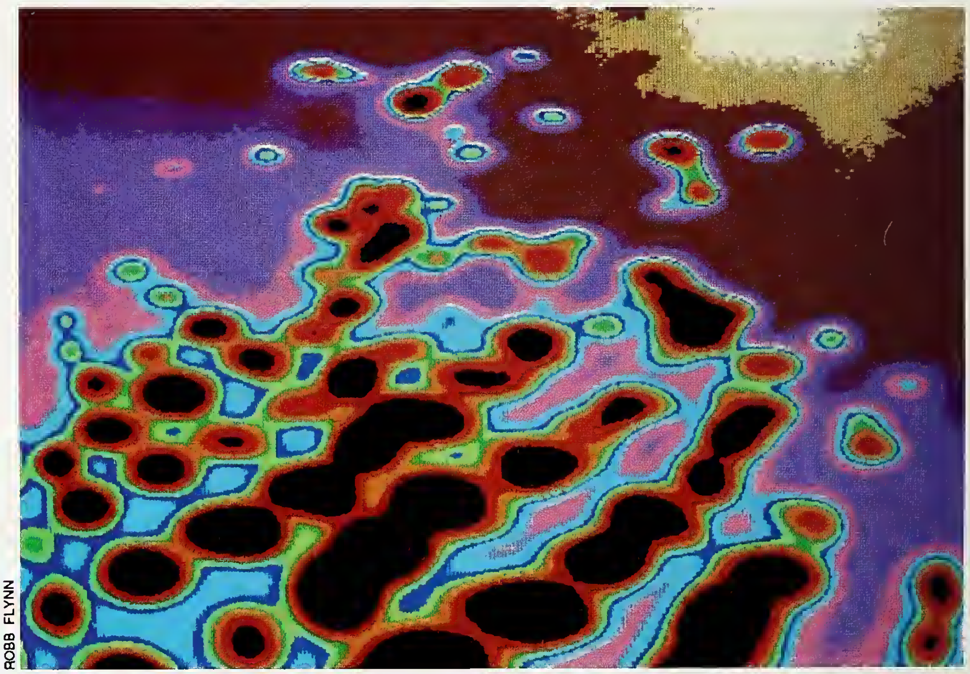
Nor is that percentage likely to change on its own, in Tyrrell's opinion.

"That's not to say there won't be some changes in the future," he adds. "When a cow consumes another calorie, she either puts it in milk or in maintaining her body. That's partitioning of energy."

But the use of bovine somatotropin, the so-called bovine growth hormone, would shift the balance in favor of milk production, says Tyrrell.

"BST acts as a repartitioning agent," he explains. "It doesn't change the basic metabolic processes going on; it just repartitions energy toward milk at the expense of body tissue. Typically with BST, you get a 15 percent increase in milk output, and it can be 30 to 50 percent short-term."

Looking ahead, "I'd say we'll see basically a continuation of the same trends of the last 50 years," Tyrrell projects. "What I see is more emphasis on tailoring milk to meet specific product demands. Genetically, you can change



ROBB FLYNN

A computer-enhanced molecular fingerprint of the Ulster strain of Newcastle disease virus. (K-3140-2)

the relative proportions of proteins—casein, albumen, globulins—in milk. Part of the reason cheeses are different from each other is the various proteins in the milk. It's in this area, altering the proportions in the milk for specific products, that we'll see a change."

Milk-producing animals might be put to even more exotic use through gene insertion, says Vernon G. Pursel, a reproductive physiologist in ARS' Reproduction Laboratory at Beltsville.

"We've been working for the past year on targeting components to the mammary glands of farm animals," explains Pursel. "Depending on what gene you insert, you could have some of the rare medical proteins produced in the mammary gland. These special proteins could be extracted from the milk and purified."

The blood-clotting factor used to treat hemophilia is an example of a rare protein that may someday be extracted from milk, Pursel says.

"During the past year, we've transferred a gene for a mouse protein into pigs. If the mouse gene functions correctly, the mouse protein will be present in the milk produced by our transgenic pigs.

"The next step will be to connect the regulatory part of the mouse gene to the structural part of a gene for a rare medical protein and thereby produce it in the milk.

"The final step will be to transfer such a gene into the dairy cow. If the regulatory part of the mouse gene works, it could also be used to modify the composition of the milk."

Preventing Poultry Diseases

Although predictions for poultry include the prospect of more disease-free production environments, scientists aren't relaxing when it comes to the future threat of poultry diseases, says Charles W. Beard, veterinary virologist at ARS' Southeast Poultry Research Laboratory at Athens, Georgia.

"We hope to determine the fundamental genetic traits of viruses that will let us predict the behavior of those viruses in poultry," says Beard. "Take avian influenza and Newcastle disease. Both have a range of disease-producing capability, from strains that won't kill any birds to ones that will kill 100 percent.

"Our goal is to come up with a genetic marker whereby we can rapidly and precisely distinguish the mild viruses from those with disastrous potential—in other words, separate the good guys from the bad guys—and relay the information on what we've found to state and federal disease control officials. In the 21st Century, we'll have that capability.

"We're also looking for DNA probes to examine bird tissue and detect minute quantities of infectious agents in chickens. If a flock has survived an infection, you could examine tissues from that flock and determine if some members are carriers.

"The philosophy has been that if the flock becomes infected with certain diseases, you kill and bury them. But that's very expensive for the producer, the government, and ultimately, the consumer.

"With probes, we could check a representative sample of the flock to see if they have any residual virus. If the sample was found to be negative, you could conceivably grow out the rest of that flock."

For sheep and swine, chickens and cattle alike, the 21st century looks bright regarding improved knowledge and techniques for fighting disease, says Alex B. Thiermann, former ARS National Program Leader for Domestic Animal Diseases.

"I don't think we'll see animals resistant to everything," Thiermann says. "But we'll be able to develop animal lines with increased resistance to certain diseases.

"It's possible that we may end up with certain genetic lines of swine resistant, for example, to African swine fever. Even if it wasn't a pig as efficient as we have today, we'd still be able to use this pig in areas where we're trying to control and eradicate African swine fever."

One of the more hopeful developments in genetic engineering against diseases involves a device Thiermann calls "the nonsense gene."

"Certain viruses, such as African swine fever virus, have the capability to incorporate themselves into the genetic material of an animal, then be carried into the animal's offspring," he explains. "But the virus has to establish itself in a particular spot on the genetic material.

"If we can occupy that "parking spot" with a nonsense gene, the virus has no place to go. Work has already been done along these lines with avian leukosis, a virus that gets into the genetic material of poultry.

"We've come up with an avian leukosis virus that is modified so it can no longer cause disease, but it can still get into the genetic material of the chicken. The birds infected with this modified virus are resistant to the nasty avian leukosis virus. The parking lot is already full."

Genetically-defined pig, like that held by ARS animal caretaker James White, will help scientists assess disease resistance or vaccine responses in the future. (K-3121-12)

The altered avian leukosis virus itself has room for genetic insertions that scientists could put to good use, says Thiermann.

"We'd like to introduce desirable genes in there—production genes, more eggs, less fat, quick growth, whatever, or genes that would produce antigens to allow birds to produce antibodies against other diseases," he says.

"Again, the chickens would pass this on to the next generation, because it's in their genetic material. We're very close to this now. All the pieces are already there."

Along similar lines, scientists have successfully taken the disease-causing power away from vaccinia virus—a relative of smallpox virus—and used vaccinia virus to carry "messages" to protect animals against other diseases.

For example, field tests are underway in Canada and Europe on a vaccinia vector vaccine for rabies. A gene was removed from the rabies virus and put in the vaccinia virus. Animals that get the non-disease-causing vaccinia virus also get the rabies gene that promotes production of antibodies against rabies without actually contracting rabies.

Still, vaccinia virus has its foes, those who worry about vaccinia virus' ability to spread from one species to another, Thiermann notes.

"What I'd like to see is this being done with a host-specific virus that infects only cattle or pigs, for example. You could insert the desirable genes into the virus or bacteria.

"In the next 30 years, we could be engineering viruses by taking disease-causing properties out and putting desirable genes in," he says. "I think we will be dealing a lot more with genetically engineered vector vaccines in the future. Once we get through the preliminary stages, we can mass-produce these at low cost."

But there are still many miles to travel before science reaches that point, Thiermann adds.

"In theory, we can cut the disease information out of any virus. But it takes a long time to study a virus and map out what each area of genetic material is responsible for. Not every virus has its disease-causing properties in the same place; every one is different."

Despite all these modern miracles, one aspect of animal production probably won't have changed much 100 years hence, says James W. Deaton, supervisory research animal scientist for ARS' South Central Poultry Research Laboratory at Mississippi State, Mississippi.

"In 100 years, there will still be scientists attempting to make the system better—more efficient, more environmentally sound, with continued good health for the consumer," Deaton says.—By **Sandy Miller Hays**, ARS

[All of the following locations are USDA-ARS.] Hudson A. Glimp is at the U.S. Sheep Experiment Station, Dubois, ID (208) 374-5306. H. Duane Norman is at the Animal Improvement Programs Laboratory, Beltsville, MD (301) 344-2334. Larry D. Satter is at the Dairy Forage Research Center, Madison, WI (608) 263-2030. Henry F. Tyrrell is at the Ruminant Nutrition Laboratory, Beltsville, MD (301) 344-2620. Vernon G. Pursel is at the Reproduction Laboratory, Beltsville, MD (301) 344-2814. Charles W. Beard is at the Southeast Poultry Research Laboratory, Athens, GA (404) 546-3432. Alex B. Thiermann was on ARS' National Program Staff, Beltsville, MD (301) 344-2774. ◆

Weed-Free Fields

"Don't rate a farmer's ability to make money on how weed-free his fields are. Some of my weedier fields last summer were my most profitable," says Agricultural Research Service plant physiologist Edward E. Schweizer.

Schweizer, a weed specialist based at Fort Collins, Colorado, cut herbicide use from 6 pounds per acre to about 1-1/2 pounds and got the same corn yield. Such a reduction in herbicide use could save a farmer growing 100 acres of corn more than $3,000.

"I got the savings because a computer program calculated how much herbicide we should apply each year, with farm profit, not clean fields, being the number one goal," says Schweizer at the Sugarbeet Production Research unit, Fort Collins.

The program, named Corn/Weed Bioeconomic Model, which was developed in cooperation with Colorado State University economist Donald W. Lybecker, considers herbicide cost, value of the crop, and number of weeds and weed seeds present.

"This model will give farmers another tool to help them operate more efficiently by eliminating unnecessary herbicide applications," says Schweizer.

Schweizer keeps weeds to a tolerable level by counting the weed seeds in soil samples before planting. If there are fewer than usual, the computer model may suggest using less herbicide or even not using any. This is because the decreased yield caused by competition from weeds would not be worth as much as the herbicide and its application costs.

Because weed seed germination depends on weather, which can vary considerably, researchers designed the program to give a follow-up recommendation after corn and weeds emerge from the soil. A quick count of weeds in the corn row is entered in the computer to determine if a post-emergence herbicide application is warranted.

Fifteen corn farmers in five Colorado counties are cooperating with

Not Key to Highest Profits

Schweizer, Lybecker, and CSU Extension weed specialist Phil Westra in a 3-year, on-farm evaluation of the computer software.

"Not only will this be a demonstration for neighboring farmers, it should result in an easy-to-use package that all computer-owning farmers can apply," says Schweizer.

The scientists also plan to refine this model to handle crop rotations that include corn, pinto beans, barley, and sugar beets. During an earlier 4-year field study to collect data for the model, Schweizer and Lybecker calculated that the crop rotation that used the least herbicide generated $44.30 per acre higher return than the one using the most.—By **Dennis Senft,** ARS. **Don Comis,** ARS, contributed to this article.

Edward E. Schweizer is in the USDA-ARS Sugarbeet Production Research Unit, 1701 Center Ave., Fort Collins, CO 80526 (303) 482-7717. ◆

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Picture-perfect cornfields like this one may be a thing of the past, if farmers of the future heed the advice of a computer weed-growth program.

Groundwater Under the Cornfields

Irrigated corn plots that had already been set up for a previous research project, the Corn/Weed Bioeconomic Model, formed an ideal site for a groundwater research project begun 2 years ago by ARS.

Bill Koskinen, an ARS soil scientist at St. Paul, Minnesota, is cooperating with Edward Schweizer in ARS' Sugarbeet Production Research unit in Fort Collins, Colorado, to monitor herbicide movement toward groundwater. Koskinen has looked at the major herbicides alachlor and cyanazine and is currently looking at 2-4-D and dicamba.

Koskinen and colleagues sampled soil down to 5 feet in the former cornfield. They found that most of these herbicides stayed in the upper 18 inches of soil, where they were degraded by soil microbes.

These microbes thrive in the constantly moist soil and are found at least as deep as 4 feet, as evidenced by laboratory degradation studies. "They can degrade pesticides before they reach groundwater," says Koskinen.

The microbes have time to act because the four herbicides studied bind to soil particles, slowing their downward movement. Although they move slowly, they are more mobile than some other herbicides.

"There appears to be no problem with these chemicals leaching as long as fields aren't overwatered," Koskinen says.

The issue of chemicals reaching the groundwater is related to economics. Although he is not studying this aspect of pollution, he is a firm believer that "it's a lot cheaper to prevent contamination than to clean it up."

Koskinen is comparing his data with predictions from a leaching (LEACHM) computer model borrowed from Cornell University. "We're expanding this model to different parts of the northern United States. Eventually the data we collect will be put into the ARS groundwater loading model, GLEAMS."—By **Don Comis,** ARS.

William C. Koskinen is in the USDA-ARS Soil and Water Management Unit, Research, 1529 Gortner Ave., St. Paul, MN (612) 625-4276. ◆

Predicting Cattle Parasite Numbers

Daniel Snyder isn't just hoping that his Holstein calves pick up plenty of internal parasites this spring and summer—he's *counting* on it.

Snyder is a microbiologist at the Agricultural Research Service's Animal Parasite Research Unit in Auburn, Alabama.

There he's riding herd on a project that could yield a computer model to help cattle producers predict how severe the parasite problem is likely to be on their pastures at specific times. Among the species under study are the brown stomach worm *(Ostertagia ostertagi);* the barberpole worm, *(Haemonchus placei);* and some of the small intestinal worms *(Cooperia).*

"We get calves that haven't been exposed to parasites, and we put them out on pastures where the infective stages of the parasites are occurring," explains Snyder. "We leave them there for 30 days, then take them off and examine them for parasites. Every month, we put out two new calves.

"From this, we can get information on the kinds and numbers of parasites on the pastures. We can also get an idea of whether there's a seasonal variation—for example, is there a higher prevalence of a certain type of parasite in the fall?"

The project was begun in August 1987 at Auburn but has grown to include study sites in central and northern Alabama and on the Gulf Coast, Snyder says.

"We want to develop the computer model using this information. Then we'll use the model to see if we can predict parasite development at different locations and times.

"This is aimed at giving the cattle producer an idea of what's out there. Hopefully, they can use this information in their management plans. For example, if they know parasites will be on the pastures in high numbers at a certain time, they won't put their cattle there then."

The model could prove useful to cattle producers in Georgia, North and South Carolina, Mississippi, Louisiana and Florida as well as Alabama, Snyder says.

"We hope to have a handle within 2 years on where the model's going—whether it could be used on the cattle rancher's own personal computer, or if it would be a matter of an Extension Service agent or a university's animal science department having it on hand to provide the answers," Snyder says.—By **Sandy Miller Hays**, ARS

Daniel E. Snyder is at the USDA-ARS Animal Parasite Research Unit, P.O. Box 952, Auburn, AL 36831 (205) 887-3741. ◆

Sugar Beets Breathe Lightly, Save Energy

Each year, 9 million tons of U.S. sugar beets lie in piles for an average 60 days awaiting processing. As they lie around, the beets are using up part of their sugar as energy.

Just breathing to stay alive during this time causes them to consume as much energy as 9 million people would require in 3 weeks on a 2,500-calorie diet.

Add to that energy waste the amount used by storage-rot fungi, and processors face a loss of 500 million pounds of sugar annually, says Larry G. Campbell, an Agricultural Research Service geneticist based at Fargo, North Dakota.

Now for the first time, Campbell and his ARS and North Dakota State University colleagues have developed for plant breeders sugar beets that respire lightly while resisting three of the most prevalent storage rot fungi.

Respiration rates of the new sugar beet breeding lines averaged 27 percent less than rates of standard commercial hybrids, and storage rot proceeded at a 55-percent slower pace. When used to produced hybrids, these breeding lines will have the potential to increase the amount of sucrose that can be recovered after storage.

Usually, plant breeders must cross a number of breeding lines to develop new varieties with numerous desired traits such as those relating to sugar yield and resistance to pests.

Campbell says, "We expect that our new germplasm, designated F1009, with multiple storage traits will expedite efforts to help farmers and processors with a more productive beet."

One of the storage rot fungi thwarted by F1009 is *Phoma betae.*


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More than a half-billion pounds of sugar may be lost while beets await processing.

This organism of decay occurs throughout the world and is prevalent along the Red River Valley in North Dakota and Minnesota. The other resisted fungi, *Botyrtis cinerea* and *Penicillium claviforme*, are probably the two most costly storage rot organisms of sugar beets on a worldwide scale.

To develop the germplasm, the scientists first randomly interpollinated 19 plants of diverse backgrounds previously selected for either low respiration or disease resistance. They harvested seed from each cross, separately identifying it as a family. After identifying family progeny with both desired traits, the researchers began the next cycle of pollination and selection.

After four cycles, Campbell found no strong relationship between storability traits and root yield or sucrose content. This would indicate that storage-trait genes can be bred into commercial varieties without loss of yield.—By **Ben Hardin,** ARS.

Larry G. Campbell is in USDA-ARS Sugarbeet Research, Northern Crop Science Laboratory, North Dakota State University, P.O. Box 5677, University Station, Fargo, ND 58105 (701) 239-1357. ◆

Active People May Need Extra Protein

Everyone knows that a physically active person needs more calories than a sedentary soul, unless the active person wants to lose weight. But is the same true for protein? For years, the experts thought not—even though protein is the raw material of muscle and sinew.

According to the National Research Council, which establishes the U.S. Recommended Dietary Allowances, there is "little evidence that muscular activity increases the need for protein." And the World Health Organization stated that "energy requirements change with activity and lifestyle [but] protein requirements do not."

Both organizations had based their daily protein recommendation primarily on studies of sedentary men and women.

However, since more and more people now engage in regular exercise, a group of physiologists at USDA's Human Nutrition Research Center on Aging at Tufts University decided to reexamine the relationship between dietary protein and exercise.

"There was evidence that a single bout of endurance exercise increased the body's breakdown and loss of proteins," says Carol N. Meredith, who led the study. "We wanted to see if people who were already adjusted to endurance exercise need more than the current RDA."

Meredith, who is now with the University of California at Davis, and her colleagues selected 12 very active men who had been running, cycling or rowing for at least 2 years.

Half of the men were in their fifties and half in their twenties because "we also wanted to see if age had any effect on protein requirements," she says. As it turned out, age didn't correlate with increased protein loss, but endurance exercise did.

The men's minimum daily requirement, averaging 0.94 grams per kilogram (about 1.5 ounces per 100 pounds of body weight), turned out to be higher than the RDA of 0.8 g/kg, which has a built-in cushion to cover the needs of nearly everyone, says Meredith. "With a similar cushion added to our value for active men, their recommended intake would be 1.25 g/kg—or about 60 percent more than the RDA," she says. (This would equal 2.03 ounces of protein per 100 pounds.)

The results did not explain why they need more, however, even though the most obvious possibilities were tested.

Fortunately, says Meredith, most men living in the United States—including the fitness zealots—don't have to worry about getting enough protein.

The average protein intake for men, according to the 1985 USDA food consumption survey, is 75 percent above the RDA. Women's average intake is 34 percent above the RDA.

No studies have been done to determine how much protein endurance-trained women need, she says.

However, certain athletes—gymnasts, wrestlers, dancers, skaters—frequently restrict their food intake to stay slim, she adds. In the process, they may be shorting themselves of needed protein.

Also, women athletes tend to diet frequently. "If they require more protein than sedentary women, they may not be getting enough from the little they eat."—By **Judy McBride,** ARS.

Carol N. Meredith is now with the Division of Clinical Nutrition, University of California, TB 156, Davis, CA (916) 752-6778. ◆

Odorless, Lasting Protection for Wool

A new wool protectant developed by an ARS scientist protects wool garments from moths and beetles longer than moth balls and doesn't leave an odor.

The protectant is made from avermectin, an anti-parasitic agent produced by a soil fungus known as *Streptomyces avermitilis*. Tests have shown that the avermectin protectant withstands moth and beetle damage for at least 5 years in a single application.

The new wool protectant has also survived washing, dry cleaning, and excessive heat and light tests for durability. Avermectin was originally developed as a medicine to prevent internal parasites in animals. It kills webbing clothes moth and black carpet beetle larvae, while repelling furniture carpet beetle larvae—the primary enemies of wool clothing.—By **Bruce Kinzel,** ARS.

Roy E. Bry is in USDA-ARS Environmental and Special Problems Research, P.O. 22909, Savannah, GA 31403(912) 233-7981. ◆

Grow-Your-Own Diesel Fuel Not Forgotten

In the event of future petroleum shortages, such as that during the oil embargo of the 1970's, America's farm tractors could continue to roll during critical times of planting and harvest. That is not due to emergency stockpiles of diesel fuel, but rather to vegetable oils researchers are studying as alternative fuel sources.

"I'm not sure when vegetable oils will be economical enough to compete with petroleum-based fuels," says Agricultural Research Service organic chemist Marvin O. Bagby. "But, at the very least, we want to have something available to us in the event of an energy emergency."

Several oilseed crops have been tested as fuel for diesel engines. Among them are soybeans, sunflower, safflower, and rape. "Of these, soybeans have been and continue to be our major emphasis," he says. "Soybeans contain about 18 percent oil and are the one major oilseed available in surplus."

Bagby, based at the Northern Regional Research Center in Peoria, Illinois, says one problem researchers are facing is that the viscosity of most vegetable oils is about 15 times that of diesel fuel, which makes difficult injecting and atomizing the product into combustion chambers.

Another difficulty, in part related to the viscosity problem, is incomplete combustion. Gradual accumulation of the fuels on engine parts results in charred deposits, and the buildup of fuel in the crankcase eventually leads to viscosity changes in the lubricating oils.

"Right now, we're looking at the fundamental chemistry of these oils to generate a more technical base from which to work," Bagby says.

Should a major energy emergency suddenly occur, he says, accelerated research and some engine maintenance modifications would allow farm tractors to operate on vegetable oils during the crisis periods of planting and harvest.—By **Matt Bosisio,** ARS.

Marvin O. Bagby is in USDA-ARS Oil Chemical Research, Northern Regional Research Center, 1815 North University St., Peoria, IL 61604 (309) 685-4011. ◆

BRUCE FRITZ

ARS chemist Marvin Bagby demonstrates the viscosity differences in various fuels, evident by the rate in which steel balls fall through columns of the fuels. (K-2609-12)

Patents

Inhibiting Nitrogen Fertilizer Loss

A new way to spoon-feed nitrogen fertilizer to plants has been developed by an Agricultural Research Service chemist.

Arvin R. Mosier says about 10 to 40 percent of the nitrogen fertilizer that farmers put on their crops escapes into the air or is carried by water below the reach of plant roots.

In North America, this loss amounts to as much as 2 million tons annually.

The loss occurs during a natural chemical process that breaks down nitrogen fertilizer into forms plants can use. Unfortunately, the process may continue faster than plants can consume its output.

Mosier invented a way to inhibit this natural process by coating calcium carbide crystals with shellac. Applied with fertilizer, the calcium carbide slowly reacts with moisture in the soil to produce acetylene. The acetylene stops the nitrification process.

"When I started my studies, I was only looking for some way to stop nitrification during laboratory studies. But after considerable tinkering, it began to look like it would work for large-scale field applications," says Mosier. He is at ARS' Soil-Plant Nutrient Research unit, Fort Collins, Colorado. Nimai K. Banerjee, a chemist from the Indian Agricultural Research Institute in New Delhi, cooperated on this research.

Key to Mosier's finding was his knowledge of how turn-of-the-century miners' hat lamps worked. Water slowly dripping onto calcium carbide caused a chemical reaction that produced acetylene, a flammable gas that in turn lit the lamps.

Mosier's challenge was to invent a way to tame this natural chemical reaction. There was no danger of

fields catching on fire if he merely applied the calcium carbide, but uncoated pellets would be used up in a few hours.

His best solution for slowing this reaction was to encapsulate the calcium carbide particles with shellac. This keeps acetylene production active for 2 to 3 weeks.

Preliminary studies suggest an application of about 20 pounds per acre with the cost of the inhibitor running about one-tenth the value of the fertilizer that otherwise would be lost.

Other nitrification inhibitors are commercially available, but they don't work on flooded fields or in soils with high organic matter.—By **Dennis Senft,** ARS.

Technical information is available from Arvin R. Mosier, USDA-ARS, Soil-Plant Nutrient Research Unit, Fort Collins, CO 80522. (303) 482-5733. U.S. Patent Application Serial Number 07/229,386, "Encapsulated Calcium Carbide as a Nitrification Inhibitor." ◆

The Perfume Fruit Flies Just Can't Resist

Vulnerable vegetable fields in California, Florida, Texas, Arizona and other Sun Belt states have a new early-warning option in case of attack by the destructive Malaysian fruit fly.

ARS scientists have found a potent new lure that males of that insect species just can't resist. The powerful compounds could be used to detect invading fruit flies and monitor their whereabouts.

Known to chemists as "cyclohexyl and cyclohexenyl aliphatic alcohols and ketones," the compounds occur in some plants. Makers of soaps and perfumes use the ketones to give a pleasing, violetlike fragrance to their products.

ARS research chemists Terrence P. McGovern, Beltsville, Maryland,

GRANT UCHIDA

Latlure is a man-made attractant that has been developed for the Malaysian fruit fly, *Dacus latifrons.*

Robert A. Flath at Albany, California, and Roy T. Cunningham, Hilo, Hawaii, have named their new attractant "Latilure," after the insect's scientific name, *Dacus latifrons.*

The fly, cousin to the notorious Mediterranean fruit fly, or medfly, is about one-third the size of a common house fly, with a rusty brown abdomen and bright yellow stripes where its wings are attached.

It is a native of Taiwan, Thailand, Laos, and the Malay Peninsula. So far it has succeeded in settling in only one state—Hawaii. In 1983, it was first spied in a few small fields of chili peppers on the island of Oahu.

Agricultural officials in California were unsettled by the fly's proximity to their state's fields of tomato, eggplant, and bell pepper—all Malaysian fly favorites. So California funded much of the research that led to the attractant.

Crops are ruined when the female fly settles on ripening vegetables, then punctures the surface with her slender, tubelike ovipositor. Eggs that she pumps through the ovipositor develop inside the vegetable into tiny white maggots that make crops unsalable.

So far, the insect has made only two forays into California—both unsuccessful.

It was found among red peppers, okra pods, and eggplants hidden in the trunk of a car that a returning sailor had shipped to the mainland. Another time the fly turned up in a package of produce mailed—illegally—into this country. The new lure increases the odds that agricultural agents in California and elsewhere will be able to find such invader flies even faster in the future.—By **Marcia Wood,** ARS.

For technical information about this patentt,contact Terrence P. McGovern, USDA-ARS, Insect Chemical Ecology Laboratory, Room 8, Bldg. 010, BARC-West, Beltsville, MD 20705 (301) 344-2138. Patent No. 07/247,546, "Attractants for *Dacus latifrons,* the Malaysian Fruit Fly." ◆

Letters

*We invite letters from readers and, from time to time, will share them in this column.—**Ed.***

On Catfish Farming: While I basically enjoyed your Aquaculture feature issue of *Agricultural Research,* I am troubled by your statement on page 2 [Can We Scale Up Fish Farming? February 1989]; "Fish are, after all, simply another animal we can grow for food." I think that is quite an oversimplification and offensive statement.

Fish are much more than that. Having kept fish as a hobbyist for over 17 years, I have observed fishes to be sensitive, responsive, and interesting creatures, with a value far beyond their use as "human food." While I hesitate to give fish human attributes, I hate to see them the next to be "factory farmed."

While I encourage the captive raising of fish for food, as a way to alleviate pressure on wild populations, I hope your research can expand as a way to help preserve and breed rare fishes for reintroduction to the wild. Much as modern zoos claim to do. Keep up the good work.

Charles A. Levine
St. Paul, Minnesota

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